

We claim:

1. A method for operating an engine with an emission control device in an exhaust system of the engine, and an air introduction device coupled to the engine exhaust system, the method comprising:

after an engine start, operating the engine with ignition timing retarded from optimal torque timing and combusting a lean air-fuel mixture;

continuing said operation until an exhaust system temperature reaches a pre-selected value; and

after reaching said pre-selected temperature value, operating the engine with a rich air-fuel mixture and commencing adding of air via said air introduction device.

2. The method recited in Claim 1 wherein said exhaust system temperature is an exhaust manifold temperature and said pre-selected value is an auto-ignition temperature.

3. The method recited in Claim 1 wherein said exhaust system temperature is an exhaust gas temperature.

4. The method recited in Claim 1 wherein said rich air-fuel mixture is richer than about 12:1.

5. The method recited in Claim 1 wherein said operating the engine with said rich air-fuel mixture and said adding of air via said air introduction device is suspended in response to an indication.

6. The method recited in Claim 5 wherein said indication is based on whether the engine is in an idle condition.

7. The method recited in Claim 5 wherein said indication is based on whether engine airflow is greater than a predetermined amount.

5 8. The method recited in Claim 1 wherein said air introduction device is an air pump.

10 9. The method recited in Claim 8 wherein a voltage applied to said pump is adjusted to control an amount of air added via said pump.

15 10. The method recited in Claim 9 further comprising determining said amount of air added via said pump based on exterior conditions.

15 11. The method recited in Claim 10 wherein said exterior conditions include at least atmospheric pressure and temperature.

20 12. The method recited in Claim 1 wherein after reaching said pre-selected temperature value, the engine is operated with ignition timing adjusted based on said rich air-fuel ratio.

25 13. The method recited in Claim 1 further comprising adjusting said rich air-fuel ratio based on an amount of air added via said air introduction device.

30 14. The method recited in Claim 1 further comprising adjusting air entering the engine when transitioning from said lean operation to said rich operation.

15. A method for operating an engine with an emission control device in an exhaust system of the engine, and an air introduction device coupled to the engine exhaust system, the method comprising:

5 in response to an indication that exhaust temperature is below a first threshold, operating the engine with ignition timing retarded from optimal torque timing to combust a lean air-fuel mixture;

10 in response to an indication that exhaust temperature is above said first threshold and below a second threshold, operating the engine to combust a rich air-fuel mixture and adding air to the exhaust system via said air introduction device; and

15 in response to an indication that exhaust temperature is above said second threshold, operating the engine near stoichiometry.

16. The method recited in Claim 15 wherein said rich operation is richer than 12:1.

20 17. The method recited in Claim 15 wherein said air introduction device is a pump coupled to the exhaust system.

25 18. The method recited in Claim 15 wherein said exhaust temperature is an exhaust manifold temperature estimated based on engine operating conditions.

19. A method for operating an engine with an emission control device in an exhaust system of the engine, and an air introduction device coupled to the engine exhaust system, the method comprising:

5 when exhaust temperature is below a first threshold, operating the engine with ignition timing retarded from optimal torque timing to combust a lean air-fuel mixture;

10 when exhaust temperature is above said first threshold and below a second threshold, operating the engine to combust a rich air-fuel mixture and adding air to the exhaust system via said air introduction device; and

 when exhaust temperature is above said second threshold, operating the engine near stoichiometry.

15 20. The method recited in Claim 19 wherein when exhaust temperature is above said second threshold, said engine is operated with ignition timing near optimal torque timing.

20 21. The method recited in Claim 19 further comprising, when exhaust temperature is above said first threshold and below said second threshold, operating the engine to combust said rich air-fuel mixture and adding air to the exhaust system via said air introduction device, and discontinuing said operation when at least one of the following conditions occur: a non-idle condition, or engine airflow is greater than
25 a predetermined amount.